birds. Hesperornis lived in a shallow tropical sea surrounding the present Rocky Mountains, then a group of islands. The modern penguins show some remarkable points of affinity to reptiles in the structure of their feet, and probably their embryonic development, when worked out, may throw much light on the past history of birds.

Some of the extinct Dinosauria which show remarkable affinities with birds were at least aquatic in habits.

The fauna of the coast has not only given origin to the terrestrial and freshwater faunas, it has throughout all time since life originated given additions to the pelagic fauna in return for having received from it its starting points. It has also received some of these pelagic forms back again to assume a fresh littoral existence. The terrestrial fauna has returned some forms to the shores, such as certain shore birds, seals, and the Polar bear; and some of these, such as the whales and a small oceanic insect, Halobates, have returned thence to pelagic life.

The deep-sea fauna has probably been formed almost entirely from the littoral, not in most remote antiquity, but only after food derived from the *débris* of the littoral and terrestrial faunas and floras became abundant in deep water. It was in the littoral region that all the primary branches of the zoological family tree were formed; all terrestrial and deep-sea forms have passed through a littoral phase, and amongst the representatives of the littoral fauna the recapitulative history, in the form of series of larval conditions, is most completely retained. It is for this reason that the researches carried on at marine laboratories on the coasts have yielded in the last few years such brilliant results.

BALLOON PHOTOGRAPHY[1]

RECENT experiments in photographic aërostation, carried out by M. Gaston Tissandier, with the assistance of M. Ducom, have been attended with very complete and satisfactory results. The photograph reproduced by heliogravure in Figs. 1 and 2 was taken at an altitude of 605 metres over Paris; others which were taken did not give such perfect results; nevertheless, some of them surpass in distinctness any yet taken by the same method. The ascent took place at Auteuil on June 19, M. Ducom attending specially to the photography, while M. Tissandier looked after the balloon. The photographic apparatus arranged in the car is shown in Fig. 3. The ascent took place at 1.40 p.m. with a south-west wind. Ten minutes after starting a first photograph was taken at 670 metres; soon afterwards another was taken at about the same height, in which a bridge, quay, public office, fifteen cabs, a tramway, and the people in the streets were clearly reproduced. At 605 metres the photograph here reproduced was obtained, but unfortunately heliogravure does not produce an exact *fac-simile* in the fineness of the details. The smaller plan (No. 2) shows the exact topography of the place. When the photograph itself is examined through a magnifying glass many details are discovered, such as the coils of a rope mooring a boat to the shore, the passers-by, &c. On the photograph, too, the chimneys may be counted forming a number of small black spots on the roofs. A picture of great clearness, but rather greyish, was taken a few minutes later at an altitude of 800 metres above the prison of La Roquette; and another at the moment of leaving Paris at 820 metres. Beyond the city two more

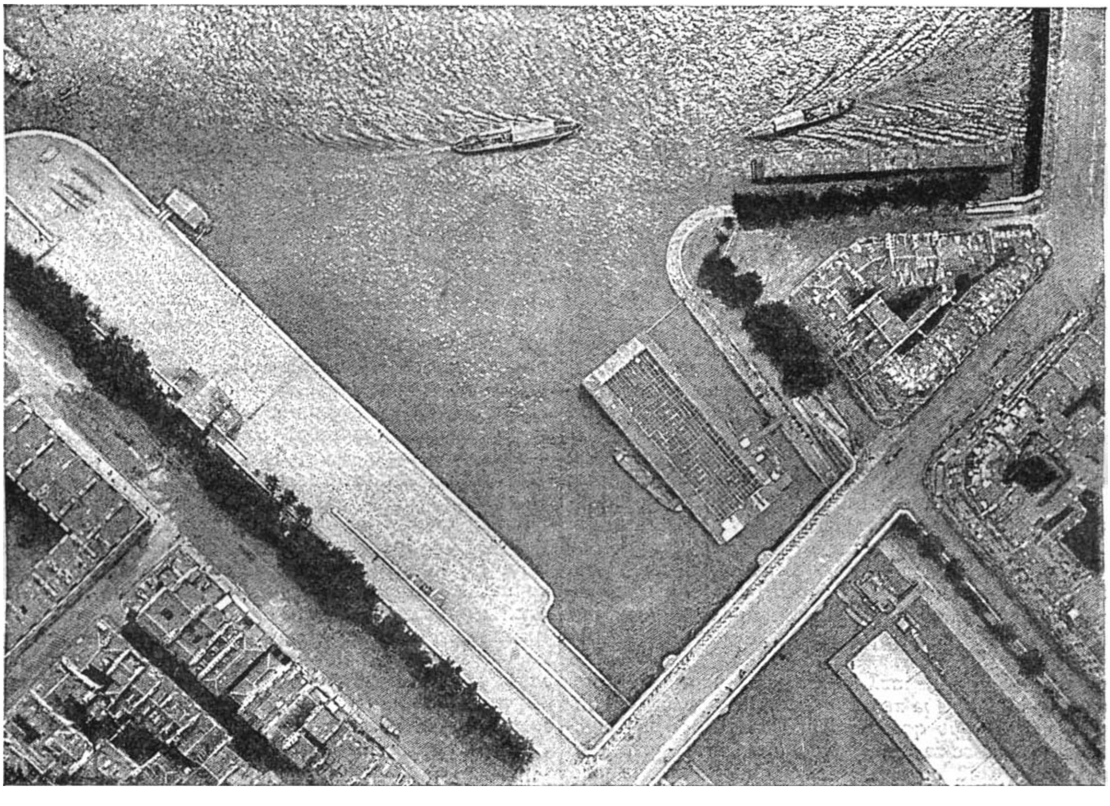

FIG. 1.—Reproduction by heliogravure of a plate taken at a height of 605 metres above Paris, showing the Seine, with two boats, Pont Louis-Philippe, gate of the Hôtel de Ville, &c.

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[1] Abstract from *La Nature*.

photographs were taken at greater altitudes—one at 1000, and one at 1100 metres. Hence in crossing Paris, between 1.40 and 2.12, or in twenty-two minutes, five photographs were obtained. It would be easy to have two or three photographic apparatus with an operator in the car for each, and thus to obtain a series of views. By this method a series of topographical documents of incomparable precision might be obtained. Amongst the views taken during this ascent those which are perfect in point of clearness are those taken at the moment when the rays of the sun fell directly on Paris. Good light is absolutely indispensable, and, in spite of the photographs being instantaneous, the car should be kept perfectly free from oscillation at the moment the picture is being taken. The operator and occupants of the car must at that moment remain perfectly still. The movement of the balloon has no injurious effect on the clearness of the proofs obtained; in the present instance the current of air was somewhat rapid, for the balloon traversed Paris at its greatest width, 11 kilometres, in thirty-two minutes. The rapidity of the wind increased subsequently to much more than this. After taking photographs of the earth below, the apparatus was turned upwards to obtain views of the clouds; but the white clouds which reflect the rays of the sun with great intensity, did not give good results. The apparatus will require special arrangement for this work, and in their next expedition the aëronaut-photographers hope to obtain something more complete than they have done. Their experience on the whole is that photographs may be obtained in a balloon as beautiful and clear as the best produced on *terra firma*. Thanks to the instantaneous process, to the extra-sensitive plates produced to-day, and to other modern improvements, aërostatic photography has a great future. It will give plans which will exceed in precision and clearness the most pains-taking maps; it will be a powerful ally of military art, for it will admit of obtaining a reliable plan of fortresses or of hostile works. At a height of 600 metres a balloon has nothing to fear from artillery fire,

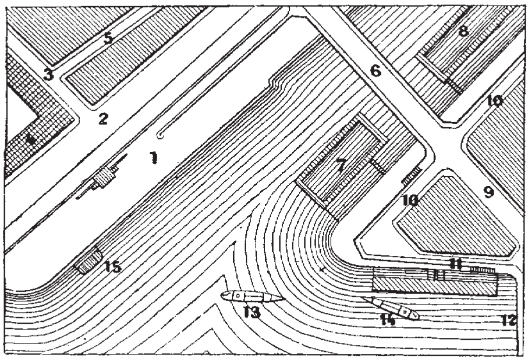

FIG. 2.—Explanatory plan of above:—1. Gate of the Hôtel de Ville. 2. Quay of Hôtel de Ville. 3. Rue de Brosse. 4. Old Lobau Barracks. 5. Rue de l'Hotel de Ville. 6. Louis Philippe Bridge. 7 and 8. Baths. 9. Rue de Bellay. 10. Quai de Bourbon. 11. Quai d'Orleans. 12. Pont St. Louis. 13 and 14. Boats. 15. Pier.

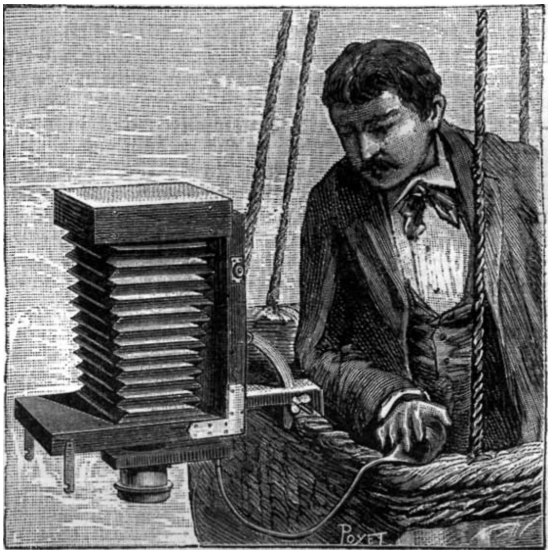

FIG. 3.—Arrangement of photographic apparatus in the balloon.

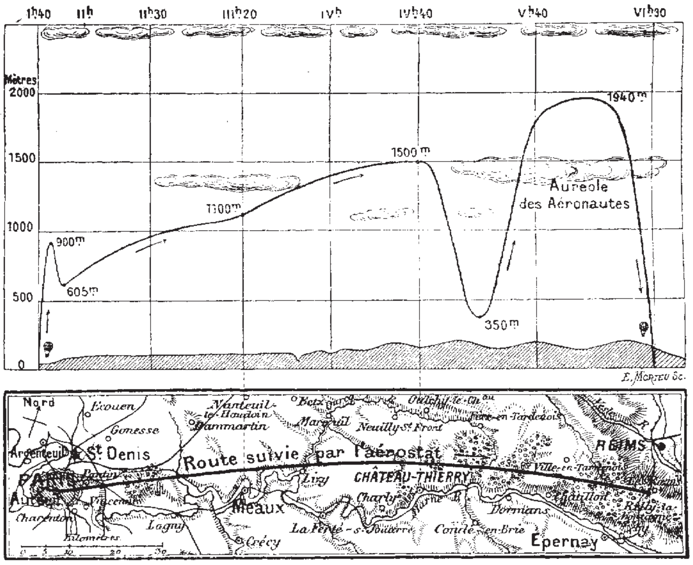

FIG. 4.—Diagram of the ascent of the "Commandant Rivière" balloon from Paris to Les Rozais, near Rheims, June 19, 1885.

and the photographer can operate as safely in his car as in his studio. It will also add to the resources of photography, for there are no places on the earth's surface inaccessible to a balloon.

The ascent here described had for its main purpose photography; but it had also some meteorological interest. The ascent began at 1.20; and at 3.20, at an altitude of 1100 metres above Meaux, another balloon, which ascended some time after them, was met with. They were actually in a frequented aëronautical route—an aërian river. At Meaux Nadar descended in 1863; M. Tissandier himself landed at the same place in 1872, and several other descents were made there. A little farther, at Château-Thierry, on a prolongation of the line from Paris to Meaux, M. Tissandier and M. de Fonvielle made an extraordinary descent in a storm in 1869, when they were dragged along the ground four kilometres in five minutes. They travelled from Paris to Château-Thierry, a distance of 80 kilometres as the crow flies, in 35 minutes—the most rapid balloon voyage on record. On the present ascent, at an altitude of 1000 to 1400 metres, an aërial current of considerable speed prevailed; it was estimated at about 40 kilometres an hour. At 1400 metres a mass of white translucid clouds stretched across the sky and floated in the upper part of the aërial current. Above this, again, the air was calm; small white clouds remained immovable at 2000 metres, and the sun was very hot. After having descended close to the earth above Château-Thierry, it was decided to rise above the clouds amongst which the aëronauts had just been. At 6 o'clock, at a height of 1900 metres, they observed the shadow of the balloon projected on a white ground of clouds; the latter formed a small greyish circle, surrounded by an aureole of the seven colours of the rainbow. When they approached the clouds, it was only the shadow of the car and of the lower part of the balloon of which the projection could be distinguished, and the aureole assumed a larger diameter. This remarkable and beautiful phenomenon resembles that of the spectre of the Brocken. At 6.10 the descent commenced; the balloon crossed the bank of clouds, and the surface of the earth, when it came in sight, looked grey and dull compared with the magnificent regions of the upper atmosphere.

RADIANT LIGHT AND HEAT[1]

III.

Radiation and Absorption—Terrestrial Applications.

HAVING now established the Theory of Exchanges, let us inquire at greater length into the nature of the radiation from bodies of different kinds. For this purpose we shall adopt the well-known classification into solids, liquids, and gases, and shall select as the type of a solid body (as far as radiation is concerned) a black substance like carbon. We must do this because, in order to obtain the greatest amount of radiation from such a body at a given temperature, it must be of sufficient depth to be practically opaque, or *athermanous*, for the heat of that temperature, and it must have a non-reflective surface. Now carbon or lamp-black possesses these properties, if not completely, yet to greater perfection than any other substance that we know of; and on this account we shall select it as the type of radiating solid bodies.

Then as regards liquids, we have no doubt an amount of surface-reflexion, which will have the effect of diminishing the radiation, and also of polarising it, to some extent. In this respect a liquid surface may be regarded as equivalent to a polished solid surface, so that liquids and polished solids may be classed together as giving out an amount of heat somewhat less than that given out by the typical black surface.

But while there is no marked distinction in radiation between solids and liquids, if only the depth of substance be sufficiently great, the radiation of gases is essentially different. This difference consists in the fact that while solids and liquids radiate all kinds of heat possible to the temperature, gases radiate only a few. We shall best perceive this distinction if we confine ourselves to rays which affect the eye, and view these by means of the spectroscope.

We have already explained how this instrument draws out a thread of white light into a parti-coloured ribbon, red at the one end and violet at the other. Now if our thread of white light be a thread of platinum, or, better still, of carbon rendered incandescent by means of electricity, we shall no doubt obtain the spectrum above mentioned. But if our source of light be a row of incandescent gaseous particles, we shall obtain something very different. Instead of a long, continuous, variously-coloured ribbon, we shall have a few discontinuous threads of light emerging from a dark background, each such thread or image having of course its proper spectral position; that is to say, if the gas gives out a yellow ray, this will appear in the yellow region of the spectrum; if a red ray, in the red region, and so on. Such spectra may either be thrown upon a screen, or viewed through a telescope—sometimes it is possible to throw them upon a screen and render them visible to a large audience, but sometimes this is not possible. In all cases, however, they may be thrown into a telescope and viewed by the individual observer.

We are thus in a position to formulate the distinguishing characteristic between the spectra of solids and liquids, and those of gases, the former giving out a continuous spectrum, consisting of all the rays of light possible to the temperature, while the latter give a discontinuous spectrum, consisting of a few bright lines on a dark background.

We can, in an imperfect manner, assign a reason for this behaviour. In a solid, or even a liquid, the various molecules are near together, so that no individual is free from the trammels of its neighbour in its vibrations. On the other hand, it is not so in a gas, or at least in a gas of which the molecules are very far from one another.

Here one individual is for the most part of its existence free from the trammels of its neighbours, and is able to vibrate after its own fashion and in a way to suit itself, just as freely as a bell, or the string of a musical instrument. It thus gives out, as it were, its own peculiar note, or series of notes, these notes being here, however, rays which have a definite place in the spectrum, instead of sounds which have a definite place in the musical scale. But whilst there is a great amount of freedom amongst the molecules of a gas, we must not carry this conception of things too far, or suppose that in a compound gas at ordinary temperatures we have nothing but a series of perfectly similar molecules practically independent of one another.

The particles or molecules of such a gas are far from being in a state of rest, and we may imagine them to be running about in straight paths, except when they are deflected by dashing against a neighbour, or against the sides of the containing vessel. It will thus be seen that the molecules are not quite free. In fact, a molecule perfectly remote from neighbours, travelling, for instance, in free space, and remote from the sun, would have no more inducement to vibrate than a bell would have under similar circumstances. It is the collision with its fellows that will generally cause it to vibrate, but it is sufficiently independent to vibrate according to its own laws. Indeed, we are in a position to assert that a great portion of that energy which constitutes ordinary heat in a gas is derived from this motion of the molecules in straight lines, while, again, the radiation of the gas is caused by the vibrations of the molecules after they have been in collision with one another, or with the sides of the containing vessel.

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[1] Continued from page 399.